

12 EUROPEAN PATENT APPLICATION

21 Application number: 82305509.0

51 Int. Cl.³: H 02 K 3/32
 H 02 K 15/12, H 02 G 15/18

22 Date of filing: 15.10.82

30 Priority: 15.10.81 US 311722

43 Date of publication of application:
 27.04.83 Bulletin 83/17

84 Designated Contracting States:
 DE FR GB

71 Applicant: BENTLEY-HARRIS MANUFACTURING CO.
 241 Welsh Pool Road
 Lionville Pennsylvania 19353(US)

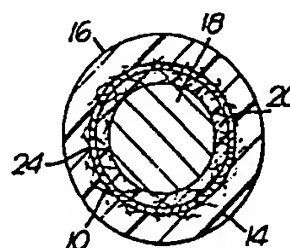
72 Inventor: Bentley, William H., Jr.
 137 Airdale Road
 Rosemont Pennsylvania 19010(US)

74 Representative: Jones, David Colin et al,
 RAYCHEM LIMITED Morley House 26 Holborn Viaduct
 London E.C.1.(GB)

64 Electrical insulation sleeve.

57 An electrically insulating, overcoated bulky sleeve comprises a tubular sleeve (10), prepared from bulky (i.e. low density, high surface area) continuous filament yarns, and having an overcoating (14). When an electrical conductor (18) is positioned therewithin, the large surface area of the bulky yarns of the interior of the sleeve (10) provides an intimate fit for an expanded range of conductor (18) diameters. Preferably an impregnation composition (24) is introduced between the overcoating (14) and the conductor (18), the large interior surface area of the sleeves retaining the impregnation composition (24) to provide a void free structure. The overcoated sleeve (16) is preferably deformable to allow pull-back and return or fold-over, and/or is conformable to accept transitions in conductor diameter.

Fig.4.



Electrical Insulation Sleeve
Description

This invention relates to electrical insulation, to a sleeve for electrical insulation and to a method for electrical insulation of electrical conductors using said sleeve.

5 The various functional devices and/or circuits within an electrical apparatus are generally electrically interconnected by elongate electrical conductors (e.g. wires, bus bars, cables, etc.) which are typically electrically insulated. Electrical insulation serves to
10 isolate the conductor from potentially disruptive environmental factors of a mechanical, electrical or chemical nature thereby insuring that current flows when and where desired without interruption:

 An electrical motor is one example of an electrical apparatus having electrical conductors which interconnect the various functional devices and/or circuits within the apparatus. The coil leads and the phase connectors which connect the quadrants of the coils of the motor for example require insulation.

20 An electrical motor also provides an example of the potentially descriptive mechanical, electrical or chemical environmental forces which may affect the conductors, and which may even cause failure of the insulation. Such insulation failure may be caused, for example, by mechanical
25 forces which may be induced by electromagnetic torque or by vibration-induced wearing-away of the insulation against other components of the electrical apparatus. Alternatively or in addition thermal expansion and contraction may cause wear and localized overheating due to the presence of air



or vapour pockets which reduces heat transfer may accelerate thermal degradation of the insulation materials and induce stress cracking. Also, oxygen or ozone from electric discharges may enter and cause oxidative degradation of
5 polymeric materials, and water may enter and corrode metal parts or short circuit conductors.

Electrical insulation to protect the conductors may be provided either before or after interconnection of the conductor within the electrical apparatus. To provide
10 insulation before interconnection of the conductor, the insulation material may, for example, be coated or extruded directly onto and around the elongate conductor. The insulation may be polymeric. Such insulation is then usually partially removed, usually from the extremities, as an
15 interconnection is made to or within the electrical apparatus. Alternatively, bare conductors or exposed interconnection points of otherwise insulated conductors may be insulated after interconnection of the conductors by coating (for
20 example, with a polymeric material), by wrapping with an insulating tape, by fitting an insulating sleeve or cap, or by impregnating a porous tape or sleeve with an insulating material such as a polymeric material either, the impregnation being effected before or after positioning the tape on the conductor.

25 Where insulation is provided by fitting an electrically insulating sleeve or cap the sleeve or cap is a tubular structure fabricated from electrically insulating materials. The simplest sleeve is a one-component tube composed of, for example, a polymeric material, a ceramic material, or
30 an interthreaded yarn (i.e. a braid, a knit, or a woven and sewn fabric).

The insulation value and wear-resistance of insulating sleeves may be improved by providing a dense,

thick-walled sleeve or a plurality of nested sleeves of varying diameters. Alternatively, composite sleeves may be employed such as a braided fibreglass sleeve overcoated with a polymeric material or a plurality
5 of overcoatings of polymeric materials.

The insulation value and wear-resistance of a sleeve may be further improved by impregnation of a porous sleeve with an impregnation composition, for example, a resin, prior to installation of the sleeve around a conductor.
10 after installation, the resin-rich pre-impregnated sleeve is compressed against the conductor thereby forcing resin out of the sleeve to improve contact with the conductor. Alternatively the interstices of the sleeve and/or the interstices between the sleeve and the conductor may be
15 impregnated with an impregnation composition, for example by means of a vacuum/pressure impregnation process wherein the impregnation composition is forced into the interstitial areas by alternately pulling a vacuum, then applying pressure.

An example of an impregnated insulation sleeve in
20 an electrical motor is now discussed. The stator of an electrical motor is generally insulated by resin impregnation applied by a vacuum/pressure impregnation process, and is preferably void-free. Resin is forced into the interstitial areas by alternately pulling a vacuum, then applying pressure.
25 Before the stator is impregnated, the motor is generally assembled and pretested. Conductor insulation must be in place during pretest where short term voltages on the order of 6,000 to 8,000 volts may be applied for on the order of a microsecond. Insulating sleeves which are deformably
30 expandable and can be pulled-back along the length of the conductor so that permanent interconnections can be made subsequent to the temporary connections of pretest, are (for this application and many other applications) generally preferred to tape or other types of retrofitted insulation.

The interiors of insulation sleeves associated with the conductors of the stator are generally resin impregnated at the same time that the stator is impregnated. Sleeve impregnation is also preferably void-free, but resin outflow due to gravity before the resin cures is known to occur and to result in an imperfect impregnation, especially where low viscosity resins are used for penetration of complex structures.

Insulation sleeves are generally selected to have the smallest possible diameter that will fit over the conductor to be placed therewithin, thereby improving the electrical insulation value and wear-resistance by improving the contact of the sleeve with the conductor. Bulky sleeves having a bulky interior, such as a braided asbestos sleeve, are known and have been used for electrical as well as thermal insulation. These sleeves provide an intimate fit with a conductor positioned therein.

The first aspect of the present invention provides a bulky sleeve for electrical insulation of an electrical conductor comprising a tubular, preferably electrically insulating, sleeve having a bulky interior, the sleeve being interthreaded, preferably braided or knitted, from bulky, continuous filament yarns, and an overcoating which is coated onto and substantially covers and seals the exterior surface of the tubular sleeve.

A second aspect of the present invention provides an electrical apparatus comprising an electrical conductor surrounded by a bulky sleeve according to said first aspect of the present invention. Preferably an electrically insulating impregnation composition is positioned substantially to fill the interior of the sleeve between the electrical conductor and the overcoating and especially preferably this impregnation is substantially void free.

A third aspect of the present invention provides a method for electrically insulating an elongate conductor comprising positioning around the conductor a sleeve according to said first aspect of the invention, the inside diameter
5 of the sleeve being such as to allow close contact of the sleeve with the conductor. The method preferably also comprising introducing an electrically insulating impregnation composition between the electrical conductor and the sleeve. The impregnation is preferably substantially void free.

10 The tubular sleeves of the first aspect of the present invention are interthreaded from continuous filament yarns. Continuous filament yarns are yarns in which each individual filament making up the yarn is of such a length that it extends substantially the entire length of the
15 filament strand. Extruded man-made organic and inorganic fibres are examples of continuous filament yarns. Continuous filament yarns are to be contrasted with staple filament yarns. The individual filaments or fibres making up a staple filament yarn are much shorter than continuous filament
20 yarns and must be spun (i.e. plied and twisted) together to form a yarn. The filaments are fibres of staple glass fibre are, for example, 15 to 38cm (6 to 15 inches) long and the fibres are filaments of staple asbestos fibre and up to 30cm (12 inches) long. All natural fibres except for silk
25 are staple fibres.

The present invention uses continuous filament yarns which advantageously may be interthreaded, for example by braiding, much more easily than staple yarns which tend to fibrillate, even though spun into a filament.

30 Furthermore, continuous filament yarns have a lower intrinsic surface area compared to the spun filaments of natural fibre staple yarns and hence absorb or surface adsorb no water, or at least much less water than natural staple fibre yarns. This is advantageous since water

detrimentally influences the electric properties of insulation and renders the insulation less desirable for electrical insulation even when such sleeving is overcoated. Moreover, any surface water must be removed before a natural staple
5 fibre yarn sleeve is impregnated with most impregnation compositions.

The overcoated bulky sleeve is preferably expandable, deforming when positioned around a conductor to allow pull-back from the end of the conductor and return or
10 fold-over. The sleeve is also preferably deformably/conformably expandable to accept conductor joints, while remaining substantially in intimate contact with the conductor by virtue of the interior bulkiness of the sleeve thereby providing a flexible cushion against wear. An electrical
15 conductor insulated with such a sleeve is preferably impregnated with an impregnation composition, the large surface area of the interior of the sleeve promoting retention of the impregnation composition.

The tubular sleeves may be made, for example,
20 by braiding or knitting, and are generally conformable and at least diametrically expandable, that is they conform to the general contours of an object, such as an elongate object, placed within and conformably/deformably expand to accept diameter transitions of an object placed within.
25 The overcoating of the sleeves is preferably a flexible and/or expandable material, for example an expandable polymeric material, such as an acrylic, urethane, vinyl, or silicone polymer, and preferably the overcoated sleeves retain some conformability and diametric expandability. The
30 overcoating moreover is preferably electrically insulating. The sleeves may be overcoated by any suitable process, such as an extrusion process or a solution coating process.

The bulky sleeves may be fabricated from bulky organic or bulky inorganic continuous filament yarns. Where they are to be used for electrical insulation of electrical conductors, the sleeves are selected to be electrically insulating. Examples of electrically insulating continuous filament yarns that may be used are electrical grades of fibreglass fibre, or polyester.

The sleeves are interthreaded from bulky continuous filament yarns, that is, yarns having a low density and a high surface area. These yarns typically have a density of about 70% or less, preferably from about 40% to about 60%, and most preferably from about 45% to about 55% of the density of non-bulky yarns of the same composition and diameter. The interior of sleeves interthreaded from such yarns are bulky and have a large surface area. The term interthreading is used herein to mean any method of threading together yarns to produce a sleeve and includes, but is not limited to, braiding and knitting.

Man-made inorganic yarns may be rendered bulky, or bulked, by known texturizing processes. Textured fiberglass yarn products are commercially available from, for example, PPG Industries, Inc., Fiberglass Division, under the product designations TEXO# and L.E.X. yarns. These textured yarns have lower density, higher bulk, thickness and coverage per pound than standard filament glass yarns, while still being of the continuous, multistrand type. Bulky, electrical grade glassfibre yarns are preferred for the bulky sleeves according to this invention, especially because of the high thermal conductivity characteristic of glassfibre, which allows rapid dissipation of heat.

Man-made organic yarns may be rendered bulky or bulked by, for example, a false-twisting process. Continuous, multi-strand polyester yarns, by way of illustration but not limitation, are twisted together
5 and heat treated to impart a shape, subsequently untwisted, and recombined, thereby producing a bulkier final yarn product. Bulky, electrical grade polyester yarns are preferred for the bulky organic yarn sleeves according to this invention, especially where a polyester impregnation
10 composition will be employed in the insulation process.

The interior bulkiness of the sleeves according to this invention allows intimate contact of the interior of the sleeve with the exterior of an electrical conductor to be electrically insulated placed therewithin. The
15 interior bulkiness provides a flexible cushion which markedly reduces insulation failure due to mechanical forces, such as vibration-induced wearing-away of the insulation against other components of an electrical apparatus, thereby extending the useful life expectancy
20 not only of the insulation but of the electrical apparatus itself.

The interior of an overcoated bulky sleeve according to this invention when positioned around an electrical conductor may be advantageously impregnated
25 with an impregnation composition, such as a polymer, for some applications. Polymers, which may be used include thermal setting resins, such as epoxies, phenolics, polyesters and urethanes. These reactive systems may be cured with time or by the application of heat, rendering the reactive
30 components into a less reactive or non-reactive thermoset resin. The large surface area of the interior of the sleeves according to this invention promotes resin retention and surprisingly, substantially void-free impregnations may be obtained.

An overcoated bulky sleeve according to this invention moreover provides a path for the introduction of impregnation composition by allowing introduction only through the open ends of the sleeve. Introduction of the
5 impregnation composition may be by gravity, by the application of pressure, by aspiration by means of a vacuum, or especially preferably by a vacuum/pressure impregnation process. When the impregnation composition is introduced by means of the vacuum/pressure impregnation process a homogeneous,
10 substantially void-free insulated electrical conductor results.

Preferably the sleeves are sufficiently expandable to allow the sleeve to be temporarily pulled-back along the electrical conductor to facilitate interconnection with the
15 electrical apparatus and then repositionable along the electrical conductor after interconnection with the electrical apparatus. Conductor interconnection with the electrical apparatus may be by means of soldering, welding, brazing, bolting, or any other means. It is especially preferable
20 that the sleeve be sufficiently expandable to allow the sleeve to be repositioned over the interconnection thereby electrically insulating the electrical conductor along its length and its interconnection with the electrical apparatus as well. The ratio of the circumference of the interconnection
25 to the circumference of the electrical conductor is generally on the order of two to one, but may be as high as three to one, such as where bus bars are overlapped and bolted together. The overcoated bulky sleeves of this invention are sufficiently deformably/conformably expandable to
30 accommodate such transitions.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

FIGURE 1 is a cross-sectional view of a sleeve according to the present invention prior to overcoating;

FIGURE 2 is a cross-sectional view of the sleeve sleeve of Figure 1 after overcoating;

5 FIGURE 3 is a cross-sectional view of the sleeve of Figure 2 after positioning around an electrical conductor;

FIGURE 4 is a cross-sectional view of the arrangement of Figure 3 after an impregnation composition has been introduced through the open ends of the sleeve substantially
10 to fill the interior of the sleeve between the electrical conductor and the overcoating;

FIGURE 5 is a perspective view, partially cut away, overcoated bulky sleeve positioned around and conforming to the contours of a rectangular bus bar.

15 Referring to the drawings, Figure 1 shows a tubular bulky sleeve 10 which has been braided from low density, high surface area, continuous filament glass fibre yarns. The sleeve interior 12 has a large surface area. Figure 2 shows the same tubular bulky sleeve 10 after
20 it has been overcoated with an overcoating 14 of an acrylic polymer, to produce an overcoated bulky sleeve 16 according to this invention. Any coating method which substantially covers and seals the exterior surface of the tubular bulky sleeve 10 is satisfactory, such as an extrusion
25 coating method or a solution coating method.

Figure 3, shows the overcoated bulky sleeve 16 after it has been positioned around an electrical conductor 18. The fit of the sleeve 16 is important. The sleeve 16 has been selected to have an inside diameter which allows
30 intimate contact of the interior of the sleeve 16 with the

exterior of the electrical conductor 18 to be insulated. Interstices 20 are defined by the continuous yarn fibres 22 of the interior of the sleeve 12 as they intimately contact the electrical conductor 18. It is the collective flexible cushioning effect of the overcoated bulky sleeve 16 which provides the desired resistance to mechanical deterioration as well as the desired electrical insulation.

Figure 4 shows the overcoated bulky sleeve 16 of Figure 3 after impregnation with an impregnation composition 24 substantially to fill the interstices 20 of the sleeve interior 12 between the electrical conductor 18 and the overcoating 14. Impregnation is produced using a vacuum/pressure impregnation process thereby providing a homogeneous, substantially void-free insulated electrical conductor 18.

15 In Figure 5, the conformable/deformable expandability of the overcoated bulky sleeve 16 according to this invention is demonstrated. Figure 5 is a cut-away perspective view of an overcoated bulky sleeve 16 positioned around and conforming to the contours of a rectangular bus bar 18. The rectangular 20 bus bar 18 has been joined to another rectangular bus bar 18' to form a butt-style interconnection 26 which has been soldered, the excess solder mass shown generally at 28. The overcoated bulky sleeve 16 has deformably expanded to accept the greater circumference of the interconnection 26.

CLAIMS

1. A bulky sleeve for electrical insulation of an electrical conductor comprising a tubular sleeve (10) having a bulky interior (12), the sleeve being interthreaded, preferably braided or knitted, bulky, continuous filament yarns and an
5 overcoating (14) which is coated onto and substantially covers and seals the exterior surface of the tubular sleeve.
2. A sleeve according to Claim 1, wherein the continuous filament bulky yarns are inorganic yarns, preferably glass fibre yarns.
- 10 3. A sleeve according to Claim 1, wherein the continuous filament bulky yarns are organic yarns preferably polyester yarns.
4. A sleeve according to Claim 1, 2 or 3, wherein the tubular sleeve or the overcoating (14) or both are electrical
15 insulating.
5. A sleeve according to any preceding Claim, wherein the overcoated sleeve (16) is diametrically expandable.
6. A sleeve according to any preceding claim, wherein the overcoating (14) comprises a polymer or a ceramic, preferably
20 an acrylic polymer or a vinyl polymer or a silicone polymer or a urethane polymer.
7. A sleeve according to any preceding claim, wherein the bulky yarns have a density of about 70% or less of the density of non-bulky yarns of the same composition preferably
25 a density of from about 40% to about 60% of the density of non-bulky yarns of the same composition and especially preferably a density of from about 45% to about 55% of the density of non-bulky yarns of the same composition.

8. An electrical apparatus comprising at least one electrical conductor (18) having a sleeve according to any preceding claim surrounding and intimately contacting said conductor.
- 5 9. An electrical apparatus according to Claim 8, comprising an electrically insulating impregnation composition (24) positioned substantially to fill the interior of the sleeve between the electrical conductor (18) and the overcoating (14).
- 10 10. An electrical apparatus according to Claim 9, wherein the impregnation composition (24) comprises a curable polymer preferably an epoxy polymer or a phenolic polymer or a urethane polymer or a polyester polymer.
11. A method for electrically insulating an elongate
15 electrical conductor (18), comprising positioning at least a portion of a bulky sleeve according to any one of Claims 1 to 7 around the elongate conductor (18), the sleeve having an inside diameter which allows intimate contact of the interior of the sleeve with the exterior of the electrical
20 conductor.
12. A method according to Claim 11, comprising substantially filling the interior of the sleeve by introducing an electrically insulating impregnation composition (24) between the electrical conductor and the overcoating.
- 25 13. A method according to Claim 12, wherein the step of filling the interior of the sleeve by introducing an electrically insulating impregnation composition (24) comprises a vacuum/ pressure impregnation process.
14. A method according to Claim 12 or 13, wherein the
30 impregnation composition (24) comprises a curable polymer, and which further comprises the step of curing the polymer.

111

Fig. 1.

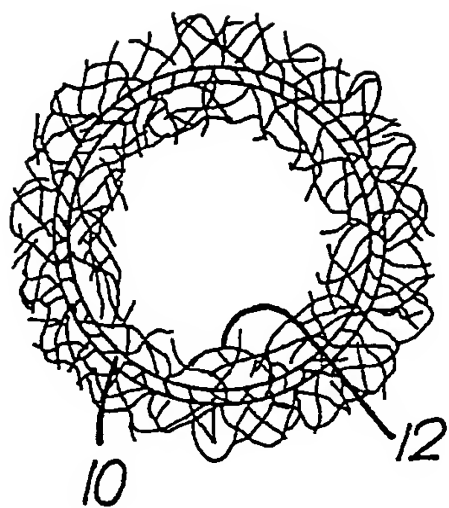


Fig. 2.

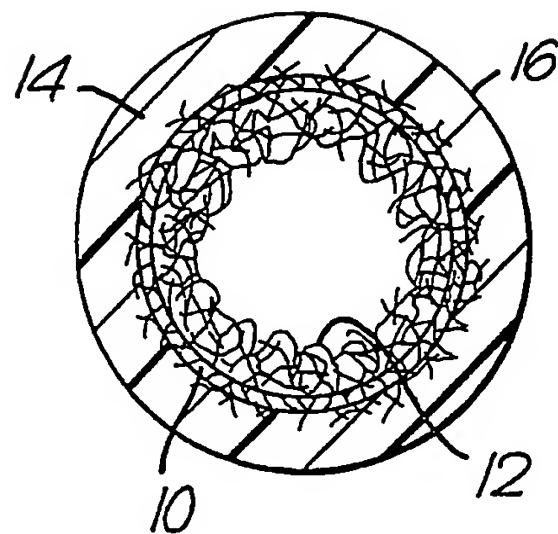


Fig. 3

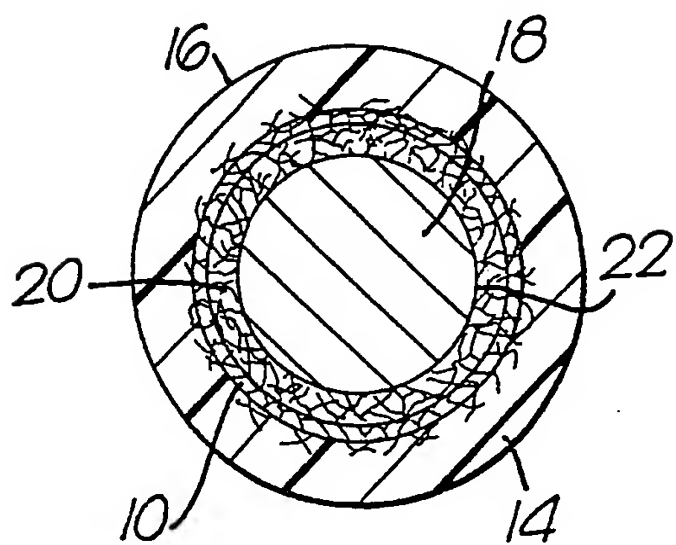


Fig. 4.

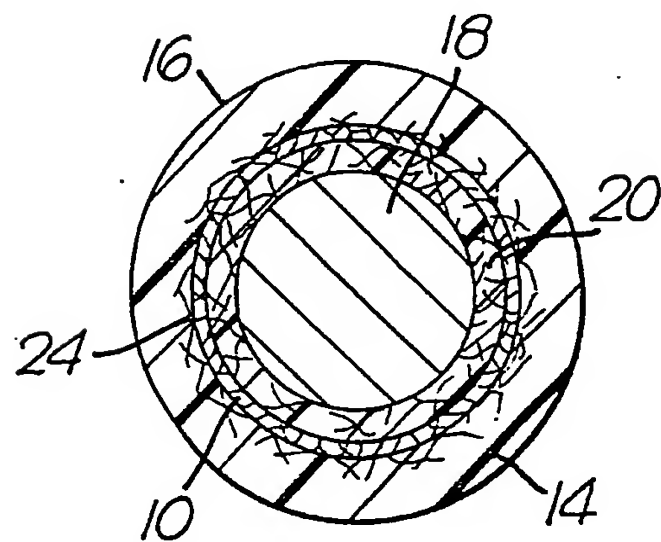
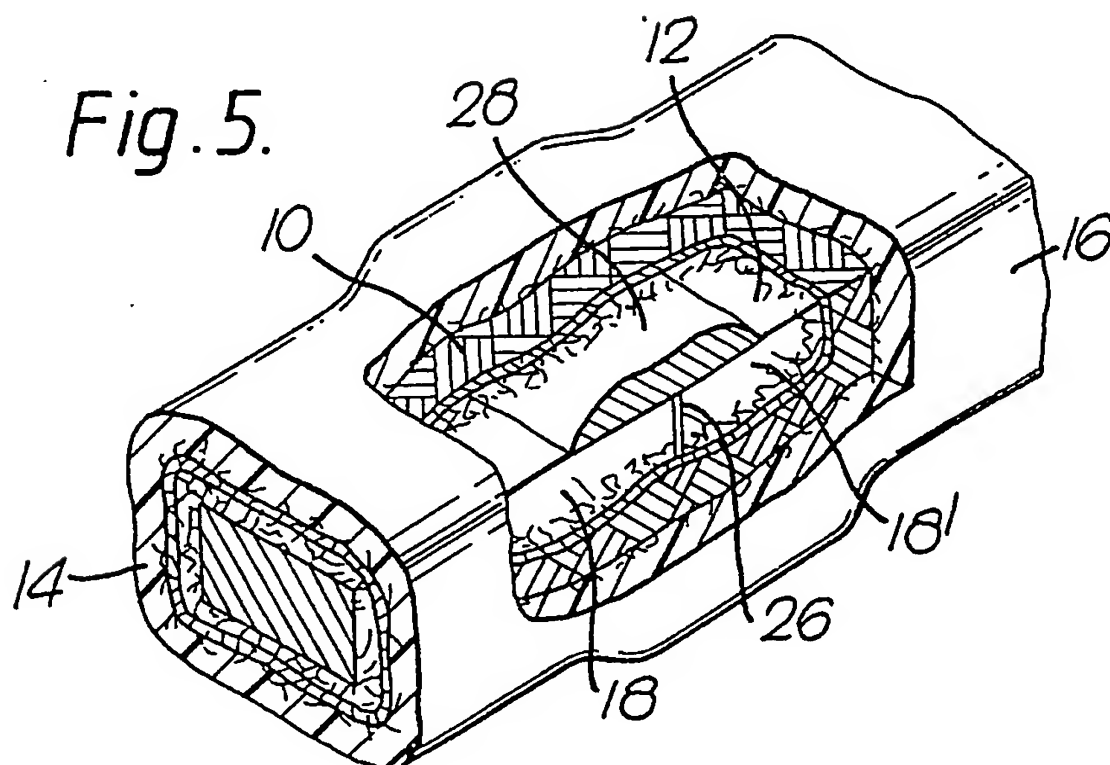


Fig. 5.





European Patent
Office

EUROPEAN SEARCH REPORT

0077665

Application number

EP 82 30 5509

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	--- US-A-2 469 099 (ANDRUS) *Column 2, line 19 to column 4, line 28; figures 1-8*	1,2,4, 6,8,9, 11,12	H 02 K 3/32 H 02 K 15/12 H 02 G 15/18
Y	--- GB-A- 943 427 (INSULATING COMPONENTS AN MATERIALS) *Page 1, line 70 to page 3, line 8; figures 1-6*	1,2,4, 8,10, 11	
A	--- PATENTS ABSTRACTS OF JAPAN, vol. 4, no. 189, 25th December 1980, page 126 E39; & JP - A - 55 132 009 (TOKYO SHIBAURA DENKI K.K.) (14-10-1980) *Abstract*	1,2,4, 8,11	
A	--- FR-A-1 417 980 (INST. FR. DU PETROLE) *Pages 1,2; figures 1,2*	1-4,6, 8	
A	--- US-A-3 462 544 (KING) *Column 2, line 9-26; figures 1,2*	1,2,11	

The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			H 02 K 3/00 H 02 K 15/00 H 02 G 15/00 H 01 R 4/00 H 01 R 7/00

Place of search
THE HAGUE

Date of completion of the search
31-01-1983

Examiner
LOMMEL A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document